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On the Dynamics and Prospects of Some Commercial Fish Stocks Recovery in NAFO Area (the Northwestern Atlantic Ocean)

by

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ABSTRACT

The dynamics and stock-spawning biomass (SSB) relationship were analyzed for cod (*Gadus morhua*) in divisions 2J+3KL, 3NO and American plaice (*Hippoglossoides platessoides*) in divisions 3LNO и 3M. These fish stocks have been at the state of a deep depression for about 15 years already. Probable reasons of this state are discussed. The similarity of the researched populations dynamics pattern have been revealed. The availability of SSB limit, below which the collapse zone (Bcoll) occurs in some stock units including the above said, was supposed. The assumed biomass levels corresponding to Bcoll are presented. The opinion was expressed that the chances for recovery of cod stock in 2J+3KL, 3NO and American plaice stock in 3LNO and 3M due to the natural processes only are minimal. The conditions and probable measures to improve this chance are considered briefly.

INTRODUCTION

It would not necessary to recall the dramatic events of the early 1990s, when several commercial fish populations abundance decreased catastrophically actually at the same time, but for one thing. This story is still far from its finish, since the stocks considered below have not been recovered until now yet. Moreover, neither signs of this process beginning have been observed. In this connection it seems relevant at least to make an attempt to clarify the situation and to make some observations concerning the probability of the stocks considered to resume the former status in the Northwest Atlantic ecosystem and the conditions required for this.

MATERIAL AND METHODS

All materials used in this work were taken from appropriate scientific documents of NAFO. Populations (stock units) of cod in divisions 2J3KL, 3NO and American plaice in divisions 3LNO and 3M were selected for research based on the similarity of their stocks abundance dynamics for the period considered and availability of sufficiently long series of retrospective data on abundance and biomass obtained using VPA methods (Baird and Bishop, 1986; Healey et al., 2003; Dwyer et al., 2005; Alpoim, 2006). As regards cod in 2J3KL (here and further the offshore stock is implied) we have to content with the estimates for the period from 1962 to 1981 inclusive. However, the latter provide relatively clear idea of this population dynamic pattern in the period preceding its collapse, therefore, these data are quite useful from the assigned task view point.

The analysis of stock-recruitment relationship (SRR) carried out using a special approach (Rikhter, 2005) (in the English version of NAFO SCR Doc. 06/3), became the methodical basis of the work, which allowed to distinguish zones of high, average and low biomass for every stock unit considered, as well as to assess approximately its limiting reference points and to determine the area of strong year-classes occurrence. The ratios of the average spawning biomass values (MSSBfav against MSSBhigh and MSSBlow) are presented in the work mentioned indicated as Ir and Il (indices describing the extent of SRR manifestation at the right end of the observed SSB respectively).

RESULTS

The relationship of spawning biomass and abundance of respective year-classes (recruits), as well as approximate boundaries of the limiting reference point Blim (the vertical dashed line); zones of high, average and low SSB (the vertical solid line), numbered as III, II and I respectively; the area of strong year-classes (the horizontal dotted line) and the level (the vertical dash-dotted line), below which, as assumed, the stock reproductive potential decreases sharply, are demonstrated in Fig. 1-4. Estimated Ir and Il are shown in Table 1. Correlation coefficients (r) between recruits abundance and biomass in the range from the levels corresponding the maximum recruitment abundance (arrows in the figures) and further up to the minimal observed SSB were calculated for every population. In all cases the initial level was in the zone III. Estimated r for cod in 2J3KL, 3NO, american plaice in 3LNO and 3M amounted to 0.73, 0.69, 0.67 and 0.30 respectively. Except for American plaice 3M, the relationship appeared reliable with 99% probability.

DISCUSSION AND CONCLUSIONS

2J+3KL cod (Fig. 1)

All strong year-classes distinguished on the basis of the criterion selected (Rikhter, 2005), appeared in the zone III only. At SSB values below 600 thous.t, mostly weak or, at best, close to average year-classes formed. In general, the effect of the density relationship within biomass range from 900 thous.t and below is traced rather clear. The similar pattern of SRR was earlier found in the Atlantic herring (Cushing and Harris, 1973). At the same time the authors expressed a concern, that such stock could be exploited up to its extinction. In this case the threshold of the limiting reference point Blim seems to be very high, probably at the level about 600 thous.t. Now let us briefly discuss probable reasons, determining the dynamics of the above said species. The extension of the exclusive economic zone up to 200 miles by Canada in 1977 was likely to justify hopes related to this drastic measure. The exploitation rate was decreased considerably and, in spite of low SSB, relatively abundant year-classes (close to the long-term average) appeared in 1978-1982. The environment conditions in this period were probably rather favorable for young cod survival. According to the data by Drinkwater et al. (2000), the water temperature anomalies integrated by depths were positive in these years. As a result, biomass increased by 1985 (Bishop et al., 1993), however it did not attain the above mentioned boundary of Blim (an important moment). However, after 1982 the long period of low temperatures (Drinkwater et al., 2000) began, which probably played an important role in subsequent appearance of several weak year-classes (Bishop et al., 1993). Besides, catches in 1983-1989 increased significantly and varied within 220-270 thous.t. (NAFO,1994). The combined effect of fishery, density relationship and environment conditions resulted in the drastic reduction of the stock considered in the early 1990s. The spawning biomass was estimated at the level of 64 thous.t in 1991, while in the next year it decreased approximately to 16 thous.t (Bishop et al., 1993). It seems that such drop of abundance had not occurred during the whole previous long-time history of cod fishery in the Northwest Atlantic No indications of any noticeable improvement have been observed up to the recent time (DFO, 2006a).

3NO cod (Fig. 2)

Evidently, all strong year-classes, except for one, occurred in the area of high biomass (zone 3). At SSB below 60 thous.t neither strong year-classes appearance has been observed. Therefore, we have nothing to do but accept the estimate of NAFO Scientific Council (NAFO, 2000), according to which the boundary of Blim is determined by the biomass level about 60 thous.t. In general, the pattern of this population abundance dynamics is similar to that of cod 2J+3KL, including the effect of the density relationship. (Rikhter, 2005). The effect of environment conditions seems to be the same. Relatively abundant year-classes 1975, 1976, 1978 and 1979 (Healey et al., 2003) in combination with low fishing mortality in 1976-1984 provided increase of SSB in the first half and middle of 1980s to the level slightly exceeding the Blim threshold (NAFO, 1994).

The first alerting symptom (the weak year-class 1980), indicating the beginning of the stock deep depression period, appeared in 1983. The abundance of all subsequent year-classes in 1980s, at best, approached to the average long-term level, however, more often it was below this level. At the same time the fishery press increased in the second half of the above said period. As a result, already in 1988 SSB level decreased below Blim boundary. During subsequent years the rapid decrease of abundance continued, and by 2003 the stock biomass decreased to 6 thous.t (Healey et al., 2003).

3LNO American plaice (Fig. 3)

Comparing the results obtained with those for the above considered cod stock units (Fig. 1, 2), it is easy to note a certain similarity of SSB relationships and recruitment (in the abundance dynamics pattern), which is confirmed by Ir and Il as well (Table 1). Therefore, it is possible to assume that collapses of the stocks of American plaice and cod in the early 1990 appeared due to the same reasons. Let turn back to the figure, which demonstrated that strong year-classes appeared in all three biomass zones, however, in the area of high biomass they appeared most often, while weak year-classes were absent almost totally. As regards zone I, no abundant year-classes below 55 thous.t., being apparently the acceptable level of Blim in this case, were observed at all.

3M American plaice (Fig. 4)

Like in the previous cases, the sharpest reduction of this stock occurred in the late 1980-early 1990, followed by a relative stabilization at a very low level (Alpoim, 2006). Strong year-classes occurrence was noted only in zone 3. One relatively abundant year-class appeared in the middle zone at SSB about 4.2 thous.t. At the lower biomass level no good recruitment was observed at all. Therefore, SSB value slightly exceeding 4 thous.t., seems to be assumed as Blim boundary. Estimates of Ir and Il (Table 1) evidence the similarity of this stock dynamics pattern with others considered above.

Now let us try to make some conclusions based on the above said.

The considered populations peculiarities, which allow to combine them into one group are the decrease of biomass in the early 1990s to the extremely low level, the absence of any recovery indications during the subsequent period and availability of the positive correlation between recruitment and spawning biomass within the main observed range of the latter. A very weak manifestation of the compensation factors effect is another feature general to the given group of fishes. It is possible to assume that for some stock units the biomass threshold exists (let us name it as Bcoll), below which a collapse zone begins, where the reproductive ability destructions becomes irreversible, or some special favorable conditions will be required to bring the stock to the norm. For cod in divisions 2J3KL, 3N0 and American plaice in divisions 3LNO and 3M this threshold may be fixed approximately at the level of 60, 30, 55 and 4.1 thous.t respectively (Fig. 1-4). At the same time for American plaice the boundaries of Blim and Bcoll coincide. The following definition is proposed for the latter reference point:

> Bcoll is the limit of the spawning biomass, below which the stock recovery probability , if any, becomes minimal, even with total fishery cessation and relatively favorable (average) environment conditions for year-classes formation.

The reference point proposed, like any other reference points, is rather conditional. At this stage of researches we are speaking not about scientifically grounded methods of its estimation, but only about the principal possibility of existing the SSB area for some populations, where deterioration of the recovery ability may become irreversible. Within the frames of the precautionary approach (Babayan, 2000) Bcoll must be interpreted only as an additional reference point to be applied in fishery management for respective populations.

Theoretically the scientists from Canada have already expresses their opinion that any reduction of reproductive ability, stipulated by the low biomass, is able to result in a very prolonged recovery process, if any, or even to lead to the stock collapse (DFO, 2006b). Certainly, the Critical zone (CZ), proposed by them according to the precautionary approach principles concerning the interpretation of the stock size impact on its productivity, is actually similar to the collapse zone. However, one important difference lies in the fact, that CZ is considered in the harvest strategy aspect, while in our case the main emphasis is put on the analysis of stock-recruitment relationship followed by distinguishing of collapse zone for populations with a certain type of density dependence.

Only after this the results obtained are related to the management strategy for respective stock units. Actually simultaneous collapse of the stock units seems to allow to speak about a predisposition of some fish populations to SSB reduction (at certain conditions) to the level, when the recovery ability destructions may become irreversible.

From the above said it follows that the main task of fishery management for fishes of this group is to maintain the spawning biomass at the level significantly above Bcoll threshold. It seems that the warning signal for introduction firm measures to the fishery restriction (including fishery ban) shall be the stock biomass reduction to Blim level.

However, at present the above mentioned task (as can be easily guessed) is not urgent to the populations considered. Instead it is worth to discuss the conditions and probable measures, which are able more or less to facilitate the stocks biomass increase to the level providing a high probability of successful reproduction.

Evidently, that environment conditions affecting recruitment abundance have to be most favorable for relatively strong year-classes formation. The most important factors in the areas of Labrador and Newfoundland may be the water temperature (abiotic factor), especially during the spawning period and at the first year of life; food supply at the early development stages and abundance of food competitors and predators (biotic factors). As we know, an important role in the stock recovery is assigned to the anthropogenic factor as well. Naturally, neither fishery of the stocks in the collapse state can be even spoken about. As follows from the data by Shelton and Morgan (2006), even by-catch of 3NO cod and 3LNO American plaice at the current conditions may become one of the serious factors preventing the stocks recovery. On the other hand, the strictly specialized, target fishery is able to decrease considerably the abundance of undesirable predators and food competitors. And finally, in the future it seems quite possible, even though in the crucial cases considered above, to provide as a supplementary measure, artificial stock recruitment until the spawning biomass attains the level corresponding to the normal natural reproduction. It seems that the current technical possibilities of aquaculture allow to maintain at satisfactory level the stocks of not only anadromous species, but also merely sea fishes.

In conclusion it is worth to say some words about the prospects of the considered stocks recovery. It is logically to assume that the longer depression period lasts, the less chance for successive recovery is left in view of probable unfavorable (for the certain population) changes of ecosystem, for example, the increase of food competitors and predators, i.e. actually the partial replacement of some species by others, which become dominating species. This process, at the worst, can appear an irreversible one. In our case the populations have already been in the collapse state for about 15 years. During this period undesirable changes could occur in the ecosystem. If it is so, the chance of natural recovery of cod in 2J3KL, 3NO and American plaice in 3LNO and 3M are minimal. The conclusions by Shelton and Morgan (2006) concerning populations considered by them are not optimistic also. Probable the development and implementation of a special program (Stocks recovery strategy) will be required to improve the chance to recover the above stocks. In the wide sense we may speak about the ecosystem approach to the live marine resources study, since without any clear knowledge about relations and interactions of the most important commercial species in a certain ecosystem, it is useless to solve the task of their fishery management with the above said approach.

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Table 1. Estimates of the mean spawning biomass (MSB) and their ratios (Ir и Il) in four fish stocks units in NAFO area .

Stock unit	MSBfav (thous.t)	MSB high (thous.t)	MSBlow (thous.t)	Ir	Il
2J+3KL cod	865	841	185.0	1.03	4.68
3NO cod	115	114	27.8	1.01	4.11
3LNO American plaice	129	168	36.5	0.77	3.53
3M American plaice	7.0	7.8	2.0	0.90	3.42

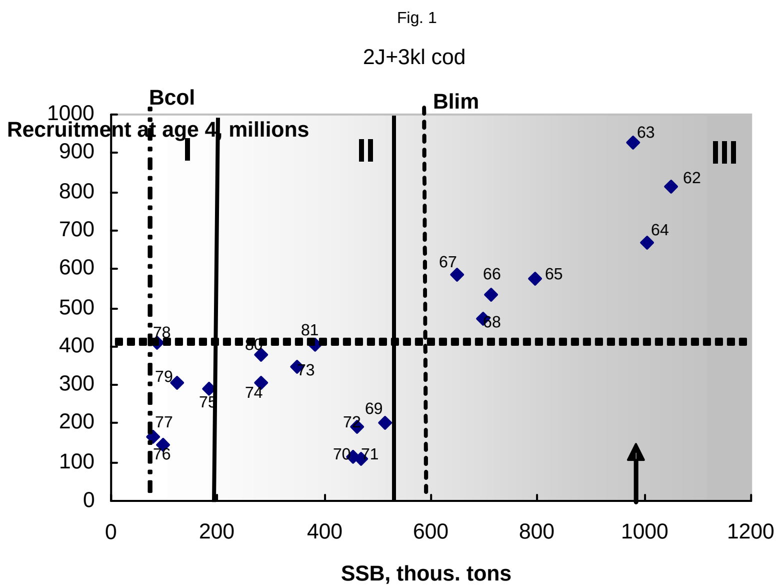

Fig. 1. Relationship of cod recruitment and spawning biomass in divisions 2J+3KL.

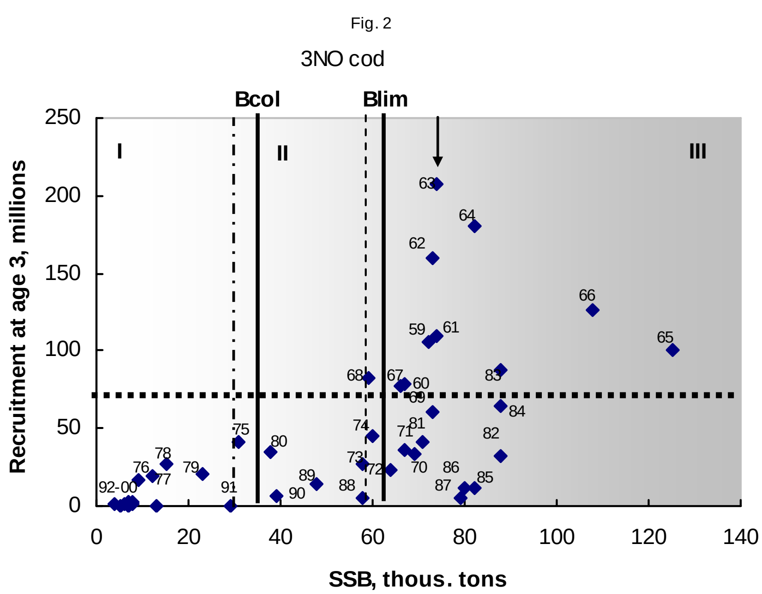

Fig. 2. Relationship of cod recruitment and spawning biomass in divisions 3NO.

Fig. 3

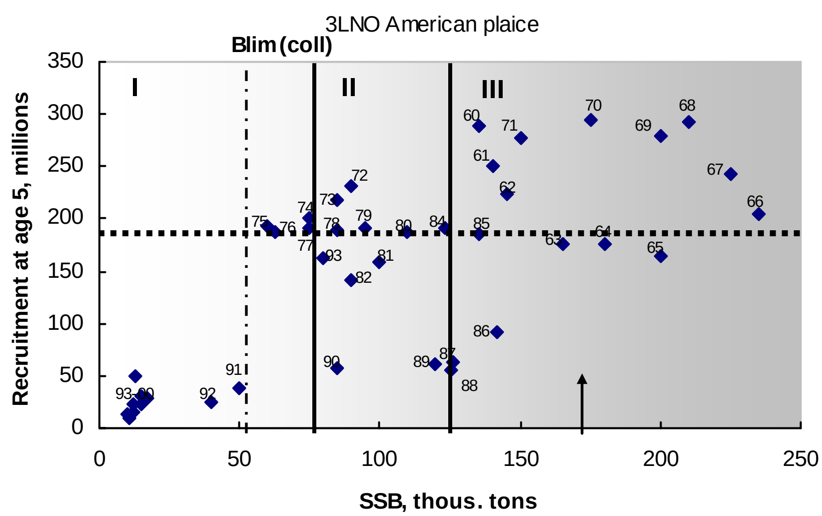

Fig. 3. Relationship of American plaice recruitment and spawning biomass in divisions 3LNO.

Fig. 4

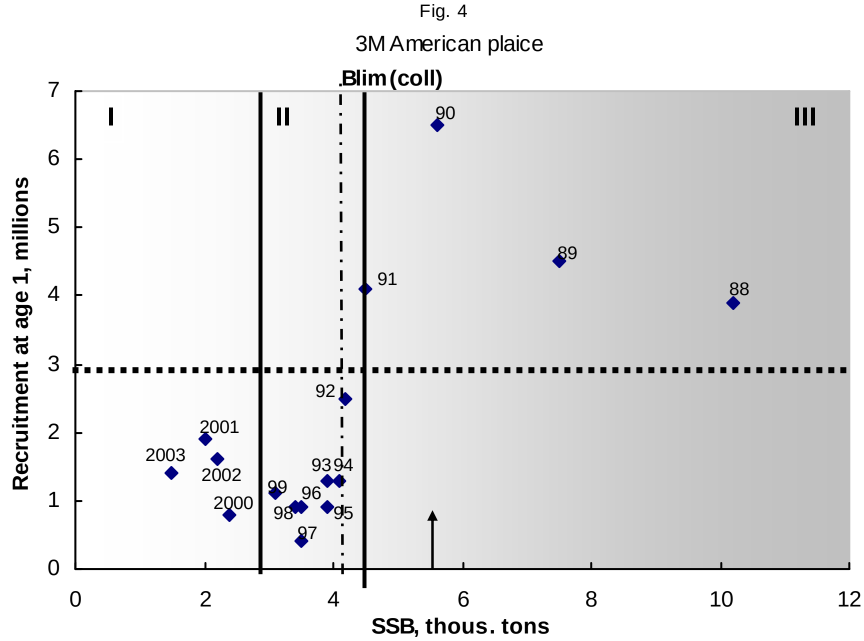

Fig. 4. Relationship of American plaice recruitment and spawning biomass in 3M.